

U.S. Department of Energy
Office of Environmental Management

**Standard Life-Cycle
Cost-Savings Analysis Methodology
for
Deployment of
Innovative Technologies**

Federal Energy Technology Center

October 30, 1998

TABLE OF CONTENTS

| | |
|--|----|
| EXECUTIVE SUMMARY | 1 |
| OVERVIEW | 3 |
| 1. INTRODUCTION | 5 |
| 1.1 Objective..... | 5 |
| 1.2 Basis..... | 5 |
| 1.3 Scope..... | 5 |
| 1.4 Limitations..... | 6 |
| 2. COST-SAVINGS CALCULATION | 7 |
| 2.1 Introduction | 7 |
| 2.2 Identifying the Basis for Comparison..... | 7 |
| 2.3 Evaluating Innovative Technologies as a Potential Replacement for Conventional Technologies | 7 |
| 2.3.1 Innovative Technologies Considered for Cost-savings Analysis..... | 8 |
| 2.3.2 Collecting Cost and Performance Data on the Innovative Technology | 8 |
| 2.3.3 Configuring the Innovative Technology to Account for Site Conditions | 8 |
| 2.3.4 Costs to Be Calculated for the Innovative Technology | 9 |
| 2.4 Evaluating Innovative Technologies Determined to Be the Best Available Option | 10 |
| 2.4.1 Cost Analysis When Innovative Technologies Have Replaced Conventional Technologies in Project Baselines..... | 10 |
| 2.4.2 Cost Analysis When Innovative Technologies Are the Only Technological Solution..... | 10 |
| 2.5 Cost Estimating Structure..... | 11 |
| 2.6 Comparative Cost Analysis..... | 11 |
| 2.6.1 Cash-Flow Schedules | 12 |
| 2.6.2 Net Present Value Calculation and Comparison..... | 12 |
| 2.7 Supplementary Cost Analyses..... | 14 |
| 2.7.1 Break-Even Time | 14 |
| 2.7.2 Sensitivity Analysis..... | 14 |
| 2.7.3 Uncertainty Analysis..... | 15 |
| 3. IMPLEMENTATION | 16 |
| 3.1 Introduction | 16 |
| 3.1.1 Use of Life-cycle Cost Analyses Results among Sites..... | 16 |
| 3.1.2 Graded Approach | 16 |

TABLE OF CONTENTS

(continued)

| | |
|--|--------|
| 3.2 Roles and Responsibilities..... | 17 |
| 3.2.1 Field Sites..... | 18 |
| 3.2.2 Technology Developers..... | 18 |
| 3.2.3 Focus Areas | 18 |
| 3.3 Data Flow | 18 |
| 3.4 Documentation and Reporting..... | 19 |
| 3.4.1 <i>ACPC</i> Reporting | 20 |
| 3.4.2 Future <i>ACPC</i> Reporting..... | 21 |
| 3.4.3 Other Reporting..... | 21 |
| 4. REFERENCES..... | 22 |
| APPENDIX A. Example of Cost-Savings Analysis..... | 23 |
| APPENDIX B. Discount Rates for Cost-Effectiveness..... | 29 |
| APPENDIX C. Glossary..... | 30 |
| FIGURES | |
| Figure 1. Cost-Savings Estimates will assist acceleration of site cleanup..... | 3 |
| Figure 2. Diagram illustrating dependence of uncertainty on project definition | 15 |
| Figure 3. Roles and responsibilities..... | 17 |
| Figure 4. Flow sheet of technology deployment decision process and data flow..... | 19 |
| TABLES | |
| Table 1. Simplified cash-flow schedules, costs in millions of dollars | 12 |
| Table 2. Cash flows and present values, costs in millions of dollars..... | 13 |

EXECUTIVE SUMMARY

The need for a standardized life-cycle cost-savings analysis methodology was specifically stated in a memorandum issued July 3, 1997 by the Assistant Secretary for Environmental Management (EM). The Assistant Secretary mandated the development of a standardized cost-savings analysis methodology by an independent entity and implementation by the field sites across the Department of Energy (DOE) complex. Each site manager is to ensure that all cost-savings analyses are performed in a manner consistent with this standardized methodology.

This methodology is targeted at innovative environmental technologies that could reduce the cost of cleanup at DOE sites across the complex. At the heart of the methodology are the following processes:

- \$ identifying the conventional technology and configuration,
- \$ identifying the innovative technology and affected components,
- \$ establishing a common basis for comparison, such as end-states,
- \$ performing and documenting life-cycle cost estimates, and
- \$ reporting the results through *Accelerating Cleanup: Paths to Closure (ACPC)* annual updates.

This methodology is designed to be generic enough for practical use across a broad range of project and technology types as well as site conditions, and builds on established site-unique cost accounting practices. For completeness, it also addresses data sources, supplementary analyses, reporting structures, and roles and responsibilities.

To calculate a cost savings, two acceptable options for addressing the problem must be identified and compared. One option will include the innovative technology (or technologies) being analyzed, and the other option will include the conventional technology commonly available for addressing the problem. The primary challenge of a cost-savings analysis is to compare the two options objectively.

Innovative technologies to be considered for implementation may be developed by private companies, the Department of Defense, DOE, or other government agencies. Innovative technologies selected for analysis should be at least in the engineering development stage. Pilot-scale demonstrations of these technologies must be either completed or under way, with engineering and cost estimates being available from these pilot tests.

The formulation of the innovative option cannot begin until cost and performance information on the innovative technology has been collected. There are a variety of sources of cost and performance data: the technology developer and/or the government agency supporting the development of the innovative technology, previous demonstration reports, independent assessments, previous customers, and industrial applications of similar processes.

All technologies will have a range of possible configurations. The configuration is affected by the application at a particular site. Two general approaches can be employed to configure the innovative technology to site conditions: (1) specify a single scenario that reflects, to the maximum extent possible, the same assumptions and site conditions as the project baseline, or (2) develop a cost-analysis model that initially reflects the same assumptions and site conditions as the project baseline but that can be easily altered, if necessary, to reflect uncertainties in site conditions or assumptions.

After the innovative technology has been configured, total cost estimates must be calculated, and annual cost and funding needs must be developed. The method for determining potential life-cycle cost savings is to perform a cost comparison between the two options. Given that the timing of costs for each option may be different, discounted cash-flow analysis must be used to equalize the effects of time. The comparison of net present values (NPVs) is the primary basis for comparing the two options for decision making. It is important to reiterate that the NPV method for estimating cost savings is primarily a comparative-analysis method for determining which technology option is preferred. The reporting of potential life-cycle cost savings should be expressed in constant dollars.

The rigor of analysis and application of this methodology should follow a “graded approach,” in keeping with the *Life-Cycle Asset Management* Order (DOE Order 430.1) and other DOE directives and policies, and OMB guidance. Thresholds for performing life-cycle cost-savings analyses will be determined by the sites. The primary responsibility for generation of cost-savings analyses has been given to the DOE field site managers, with input and support from technology developers, focus areas, and possibly others.

The *ACPC* reporting process was selected as the mechanism for reporting life-cycle cost savings from the potential implementation of innovative technologies. Future updates or replacement of the *ACPC* may require revision of this reporting guidance. Using *ACPC* for reporting is expected to provide the following benefits:

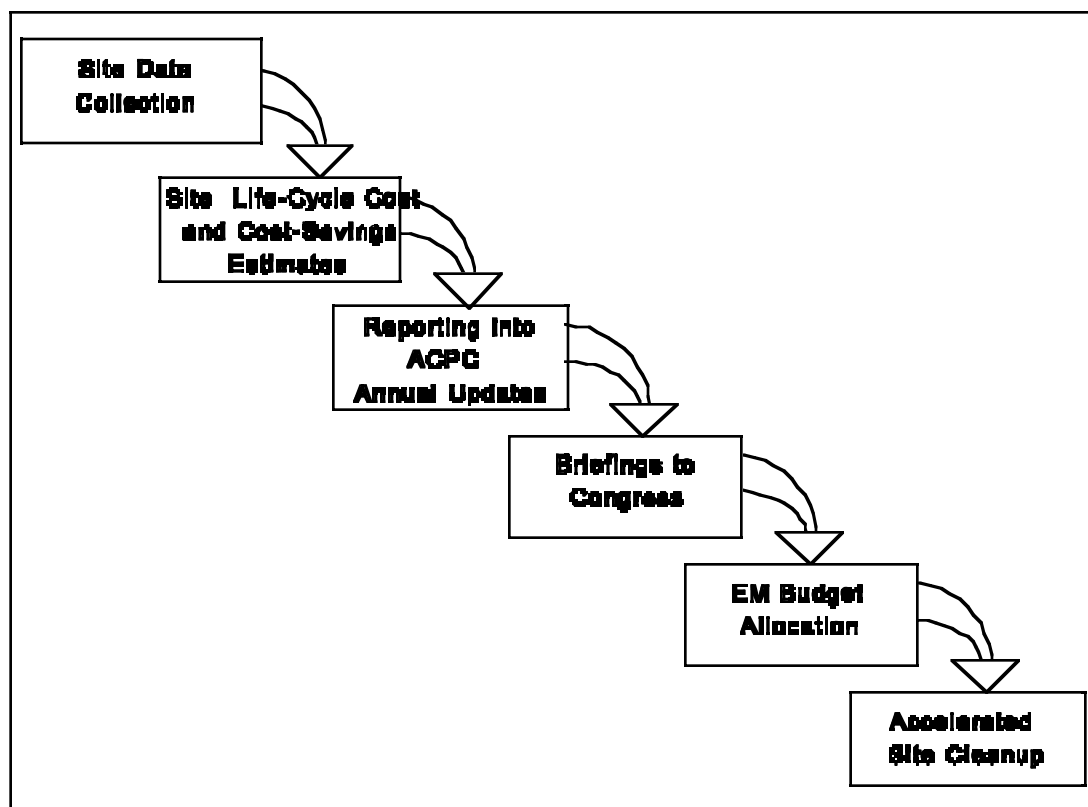
- \$ consistency of data (because a separate reporting system is not required),
- \$ cost-effectiveness (because a separate organization and data repository need not be created),
- \$ reduction of burdensome multiple reporting.

Table O.9.3 should be used to report the estimated life-cycle cost savings from potential deployment of innovative technologies. This table should be updated annually along with other *ACPC* updates and submittals.

OVERVIEW

In the July 3, 1997 memorandum on technology deployment from the Assistant Secretary for Environmental Management, ten major points were outlined to accelerate the deployment of new technology. The fifth item identified the need for a standardized cost-savings analysis methodology and data-collection process to estimate potential cost savings that might result from the deployment of innovative technologies. The memorandum assigned Federal Energy Technology Center-Center for Acquisition and Business Excellence the lead in developing the methodology and each site manager the responsibility for using it or one consistent with it.

In accordance with the EM-1 directive, a cost savings methodology was developed and is presented in this report. It is intended to assist sites in meeting their responsibility relative to determining and reporting potential life-cycle cost savings resulting from the deployment of alternative technologies from any source in accordance with a standard manual of practice, all in support of the *ACPC* document and process and ultimately in support of accelerated and more efficient site cleanups (see Figure 1). It is the collaborative effort of a cadre of federal and contractor cost professionals, with significant input from across the complex, particularly from site personnel knowledgeable of current site costing policies and practices. It is consistent with *ACPC* guidance with respect to documenting cost savings.



Since work scope, establishment and maintenance of baselines, change control, cost estimating, addressing budget constraints, and reporting are all site responsibilities, this methodology is necessarily site centered. The methodology is user friendly, drawing on established site cost accounting practices and procedures, and is fully expected to improve in clarity and completeness with the experience and insight gained through complex wide use. This methodology allows a cost savings to be estimated from a comparison of costs for conventional vs. innovative cleanup options at one site. These costs and the savings will depend upon site-dependent variables which preclude a quantitative comparison of savings estimated at another site, even if the same conventional and cleanup options are used.

The reporting of potential cost savings is not burdensome to the sites as it does not introduce any new reporting structure. The methodology recognizes that the sites currently have processes in place that support reporting of cost savings into Table O.9.3 of the *ACPC*. The sites are encouraged, however, to retain the cost estimates of innovative technologies that are not chosen for deployment in the event that other sites may have an interest in those technologies.

1. INTRODUCTION

1.1 Objective

The objective of this document is to provide a standardized methodology for estimating and reporting the potential life-cycle cost savings associated with technologies that are considered as alternatives to current conventional technologies within the EM program. The potential life-cycle cost savings can then be used to support management decisions, project planning, and *Accelerating Cleanup: Paths to Closure (ACPC)* updates. This document represents one piece of EM's larger effort to aggressively deploy viable innovative technologies and to achieve long-term cost savings. In meeting this objective, the methodology

- \$ is generic enough to apply to a wide range of innovative technology types;
- \$ promotes cost analyses that are systematic, thorough, and consistent across multiple sites;
- \$ builds on state-of-the-art and current DOE field site costing practices;
- \$ addresses responsibilities of the entities involved in the cost-savings analysis process; and
- \$ addresses documentation and reporting requirements.

1.2 Basis

The need for a standardized life-cycle cost-savings analysis methodology was specifically stated in a memorandum issued July 3, 1997 by the Assistant Secretary for EM. The Assistant Secretary mandated the development of a standardized cost-savings analysis methodology by an independent entity and implementation by the field sites across the DOE complex. Each site manager is to ensure that all cost-savings analyses are performed in a manner consistent with this standardized methodology.

1.3 Scope

This methodology is targeted at innovative environmental technologies that could reduce the cost of cleanup at DOE sites across the complex. It is equally applicable to other new technologies that may not reduce cost but are being considered as replacements for conventional technologies because they reduce risk, meet regulatory goals, enhance performance, etc. At the heart of the methodology are the following processes:

- \$ identifying the conventional technology and configuration,
- \$ identifying the innovative technology and affected components,
- \$ establishing a common basis for comparison, such as end-states,
- \$ performing and documenting life-cycle cost estimates, and
- \$ reporting the results through *ACPC* annual updates.

This methodology is designed to be generic enough for practical use across a broad range of project and technology types as well as site conditions, and builds on established site-unique cost

accounting practices. For completeness, it also addresses data sources, supplementary analyses, reporting structures, and roles and responsibilities. See Appendix A for a sample life-cycle cost savings analysis.

1.4 Limitations

Many other benefits, such as reduced health risk, schedule acceleration, and enabling of technology capabilities, are potentially achievable with the implementation of innovative technologies. However, this document applies only to cost savings. Likewise, the document does not assert that cost savings should be the overarching criterion in choosing an innovative technology for deployment. It is recognized that regulatory compliance, stakeholder concerns, reduced risk, etc. may be more important than cost savings to the decision maker.

While intersite cost comparisons would benefit the complex, direct comparisons between sites is difficult because of the number of variables involved, including differing cost accounting practices, contract types, organizational structure, code of accounts, and work breakdown structures. It is outside the scope of this document to develop and promulgate a single, comprehensive standardization policy or capability for cost estimating and accounting that considers all these independent variables.

This methodology assumes a reporting structure such as that contained in the *ACPC* report. If the *ACPC* reporting structure is no longer used, the methodology is still valid, but the reporting structure will need to be revised. The methodology is not intended to replace technology “go/no-go” decision models, such as the Office of Science and Technology (OST) “gate” process.

2. COST-SAVINGS CALCULATION

2.1 Introduction

This section describes the methodology for developing standardized and credible estimates of life-cycle cost savings that might result from the implementation of innovative technologies. To calculate a cost savings, two acceptable options for addressing the problem must be identified and compared. One option will include the innovative technology (or technologies) being analyzed, and the other option will include the conventional technology commonly available for addressing the problem. Here, these two alternatives are called “the innovative technology option” and “the conventional technology option.”

2.2 Identifying the Basis for Comparison

The primary challenge of a cost-savings analysis is to compare the two options objectively. To ensure fairness, factors common to both options (waste volumes, performance levels, labor rates, key assumptions, etc.) are held equal, to the maximum extent possible. Also, the analysis must consider that an innovative technology may be a subsystem within a larger system. Therefore, it is important to use a systematic approach to account for the “upstream” and “downstream” effects that an innovative technology might have on other parts of systems, such as permitting, monitoring, characterization, and waste disposal. In other words, *total* life-cycle costs from both options should be determined.

It is assumed that the sites have developed project baselines, or are in the process of doing so. Project baselines may or may not include the innovative technology or technologies under analysis. In either case, identifying the project baseline is fundamental to the development of the comparison of the options and the resulting cost-savings analysis. The project baseline contains the reporting structure that will be used to compare the two options. Also, the project baseline should encompass the life-cycle costs (i.e., all the anticipated costs associated with the project throughout its life) to include procurement, mobilization, installation, operations, waste management, surveillance and monitoring, and site closure activities.

2.3 Evaluating Innovative Technologies as a Potential Replacement for Conventional Technologies

Opportunities for the application of innovative technologies exist when technologies, processes, or subsystems in a project baseline are being considered for replacement or modification. For clarity, this subsystem of the existing project baseline is treated here as the conventional technology option. In other words, the conventional technology option is that portion of the existing project baseline that will be replaced by the innovative technology option. The innovative technologies considered under this category are currently referred to as “enhanced performance” or “EP” technologies in the current *ACPC* guidance.

2.3.1 Innovative Technologies Considered for Cost-Savings Analysis

Innovative technologies to be considered for implementation may be developed by private companies, the Department of Defense, DOE, or other government agencies. Innovative technologies selected for analysis should be at least in the engineering development stage. Pilot-scale demonstrations of these technologies must be either completed or under way, with engineering and cost estimates being available from these pilot tests. Cost-savings analysis can be performed on technologies at earlier stages of development if the data to support these analyses are available.

2.3.2 Collecting Cost and Performance Data on the Innovative Technology

The formulation of the innovative option cannot begin until cost and performance information on the innovative technology has been collected. There are a variety of sources of cost and performance data: the technology developer and/or the government agency supporting the development of the innovative technology, previous demonstration reports, independent assessments, previous customers, and industrial applications of similar processes. It is in the best interest of the technology developer and supporting agency to provide the site with the most complete and accurate data package they can assemble. Other data sources include Technology Deployment Management Plans prepared by field sites, the Technology Management System developed by the Office of Science and Technology, and focus area Innovative Technology Summary Reports.

2.3.3 Configuring the Innovative Technology to Account for Site Conditions

All technologies will have a range of possible configurations. The configuration is affected by the application at a particular site. It is also recognized that demonstration data for an innovative technology can be very limited. Demonstration-scale cost, schedule, and performance data may not necessarily represent what can be expected if full-scale site deployment were pursued. Beyond the immediate scale of the application, deployment site variables such as waste composition, site dimensions, climate, geology, and local regulations are likely to be different from those encountered during previous uses (or demonstrations) of the innovative technology.

Two general approaches can be employed to configure the innovative technology to site conditions: (1) specify a single scenario that reflects, to the maximum extent possible, the same assumptions and site conditions as the project baseline, or (2) develop a cost-analysis model that initially reflects the same assumptions and site conditions as the project baseline but that can be easily altered, if necessary, to reflect uncertainties in site conditions or assumptions.

Single Scenario. The first approach is to specify a single scenario that reflects, to the maximum extent possible, the same assumptions and site conditions as the project baseline. Cost and performance estimates from previous demonstrations of the innovative technology are adjusted to reflect the scale and conditions of the project baseline. The reliability of these adjusted estimates increases as the certainty and quantity of data on previous applications increases. If there have been numerous demonstrations of an innovative technology, it raises the probability that similar

site conditions have been previously encountered and that cost/performance estimates for the new site can be interpolated within the bounds of experience. In reality, however, innovative technologies usually have not been demonstrated over a large range of applications, so any new life-cycle cost estimate unique to a site will need to be determined largely via extrapolation based on limited data/experience and on sound engineering judgment. For example, general scaling factors for processing equipment are found in numerous publications. The cost engineer must judge how these factors should be applied.

Cost-Analysis Model. The second approach for configuring the innovative technology is to develop a cost-analysis model that can easily accommodate any number of scenarios. The modeling approach is preferred if the project baseline is not well defined or if new information is likely to alter the project baseline. Good cost-analysis models can accurately portray the relationships among important functional attributes and cost drivers across the appropriate range of conditions. Among the important factors and drivers are mass flows, treatment capacity, operational periods and availability, labor types and amounts, infrastructure, installed equipment costs, power, maintenance requirements, site closeout, and salvage value. Site characteristics input also should be included. Above all, development of the model requires sound engineering judgment and the documentation of all assumptions.

The technology developer or supporting agency may already have developed a cost model of the innovative technology. For instance, focus areas develop cost models to support their technology-review process. However, the use of previously developed models without thoroughly understanding the underlying data and assumptions is not appropriate.

2.3.4 Costs to Be Calculated for the Innovative Technology

After the innovative technology has been configured, costs must be calculated, and annual cost and funding needs must be developed. For the purposes of this methodology, any costs incurred before the time of the analysis, including research and development (R&D), are considered sunk and are not included in the cost estimate. However, any additional R&D required by the sites for their implementation should be included in the cost estimate.

Following R&D activities, a number of preconstruction costs such as environmental studies, design, and permitting are generally required. Capital costs include all mobilization- and construction-related costs and include all the labor, equipment, materials, and supplies necessary to bring the technology into operation. Construction costs may also include preoperational testing of new equipment, material shipping, health and safety, and site preparation. Once operations begin, maintenance, labor, and consumables (including fuel and power) are considered operating costs. Project closeout, site restoration, and salvage value can also be considered as part of the operating cost.

Direct and indirect costs must both be accounted for and included in the capital and operating costs. Direct costs include the actual labor, equipment, material, and supplies required to

complete the task. (For a more complete listing of capital and operating cost categories for remediation-type projects, see Federal Remediation Technologies Roundtable 1995, *Guide to Documenting Cost and Performance for Remediation Projects*.) Indirect costs are those that cannot be allocated to any direct cost item. Indirect costs typically consist of office overhead, general and administrative costs, applicable taxes, and fees or profit.

2.4 Evaluating Innovative Technologies Determined to be the Best Available Option

A previous evaluation may have determined that an innovative technology is clearly superior to a conventional technology and the project baseline now includes the innovative technology. In other cases, conventional technologies do not have the capability to solve the problem and the innovative technology is the only available option. In either event, an innovative technology option is considered by the site to be the best available option for solution of the problem. Evaluating innovative technology cost savings in these instances incorporates many of the aspects outlined in Section 2.3 (above) with a few important differences.

2.4.1 Cost Analysis when Innovative Technologies have replaced Conventional Technologies in Project Baselines

If an innovative technology has been incorporated into the baseline (referred to as “baseline” or “B” in the current *ACPC* guidance) and a cost-savings analysis was completed during evaluation of the innovative technology, no further analysis is required. However, if the previous cost-savings analysis does not conform to this guidance, the site may decide to compare the current baseline (which is actually the innovative option) with a previous baseline that included a conventional technology.

If previous baselines are not available or acceptable, sites can use a hypothetical conventional option that could have achieved the same results had the innovative technology not been available. If a hypothetical option is used for comparison, the guidance outlined in Section 2.3 for evaluating the cost of innovative technologies should be applied to conventional technologies. This exercise allows sites to capture cost savings that would otherwise not be reported and furthers DOE’s assessment of the technology development program. It also provides an approach for revising and documenting potential cost savings that, in the site’s opinion, may no longer be valid.

2.4.2 Cost Analysis when Innovative Technologies are the only Technological Solution

Some DOE environmental problems are so intractable that new technologies must be specifically developed to deal with the issue. In other words, there is no conventional technology (regardless of cost) with the technical capabilities to solve the problem. In such cases, the newly developed innovative technology is sometimes referred to as an “enabling technology.”

The sites should still analyze the costs of the enabling innovative technology as outlined in Section 2.3. The cost estimate of the innovative technology will provide valuable information for the site's decision regarding implementation of the innovative technology. Also, under this condition, the site may be able to show cost savings for the innovative enabling technology.

Although no conventional technologies exist for the solution of the problem, the site may still be able to identify mitigating measures consisting of techniques or processes to prevent the problem from worsening. Examples of mitigating measures include storage, long-term surveillance and monitoring. Less than full resolution of the problem may result in regulatory costs, fines, and penalties. The life-cycle costs of the mitigating measures, fines, and penalties will be compared to the life-cycle costs of the innovative enabling technology. Some of these costs may not have a finite period, and the site will have to assume an end point for comparison analysis. The basis for the period assumed should be documented. One example of an assumed duration could be the duration of the *ACPC* life-cycle planning. Previous site experience with similar applications of the mitigating measures should be utilized to the maximum extent.

For example, certain forms of mixed waste cannot be treated with conventional technologies. Innovative enabling technologies are being developed to solve the problem. Mitigating measures for these wastes include repackaging, long-term storage, and surveillance and monitoring.

2.5 Cost Estimating Structure

For each option, it will be necessary to develop a cost estimate that includes all elements to a level of detail sufficient to allow an accurate comparison and reporting. One of the most widely accepted methods is a standardized work breakdown structure (WBS). A WBS lists categories under which work elements are broken down into further detail. It provides a system for organizing the cost estimate. The WBS can also be seen as a checklist to ensure the inclusion of all elements: procurement, mobilization, installation, operation, waste disposal, and site closure.

The WBS concept was designed to help manage work systematically. For this methodology, the WBS should be used as a template or checklist to gather the applicable costs systematically in a standardized form. This methodology recommends the use of a similar WBS for analysis of the conventional and innovative technology systems. This will allow similar work elements to be assigned the same identification number, ensuring that the cost comparisons carried out are balanced to the maximum degree possible. It is recognized that different sites currently employ a variety of WBS structures, but it is not within the scope of this methodology to standardize them.

However, through its participation in the Interagency Cost Estimating Group (ICEG), EM is considering the use of a WBS called the "Hazardous, Toxic, and Radioactive Waste Work Breakdown Structure" (HTRW WBS). It is recommended that the HTRW WBS format, when finalized, be used where an existing WBS is not in place. It is not suggested that established WBS systems be replaced with the HTRW WBS. However, it is recommended that sites examine their

WBS when conducting comparative analyses to determine whether the WBS structure can be modified to more closely reflect the HTRW WBS system.

2.6 Comparative Cost Analysis

As previously mentioned, the method for determining potential life-cycle cost savings is to perform a cost comparison between the two options. Given that the timing of costs for each option may be different, discounted cash-flow analysis must be used to equalize the effects of time. The comparison of net present values (NPVs) is the primary basis for comparing the two options for decision making. It is important to reiterate that the NPV method for estimating cost savings is primarily a comparative-analysis method for determining which technology option is preferred. The reporting of potential life-cycle cost savings should be expressed in constant dollars. If cost savings are reported in escalated dollars, the escalation rate used must be explicitly stated. If cost savings are reported as NPV, the OMB discount rate used must be explicitly stated.

2.6.1 Cash-Flow Schedules

After conventional and innovative options have been identified and the costs have been calculated, deployment cost schedules can be developed. These schedules must be sufficiently detailed to enable creation of a yearly cash flow for each option. The schedules must be consistent with all activities present in each option (e.g., characterization, treatment and disposal, deactivation, surveillance, and maintenance). The schedules must show the anticipated net cash flows (sum of cash outflows and inflows) that are associated with each year of deployment. In most cases, cash flows for environmental remediation projects will be outflows, consisting of capital costs and operation-and-maintenance costs associated with technology deployment. Salvage value, if any, is considered a cash inflow. Table 1 shows simplified cash-flow schedules for sample conventional and innovative options.

Table 1
Simplified cash-flow schedules, costs in millions of dollars

| Option | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 |
|---------------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <i>Conventional</i> | 10.0 | 2.5 | 4.0 | 4.0 | 4.0 | 2.0 |
| <i>Innovative</i> | 12.0 | 1.5 | 1.5 | 1.5 | 3.0 | 0 |

Cash flows can be expressed in either constant- or escalated-dollar amounts. Constant dollars represent the amount of purchasing power required for future tasks as if the tasks were to be paid for at present. Constant dollars are not escalated for anticipated inflation. Escalated dollars, on the other hand, represent the amount of purchasing power required for future tasks given an assumed rate of inflation. Cash-flow analyses must not mix constant- and escalated-dollar estimates.

It is important to remember that cash-flow schedules developed for both options must be consistent with planned budgets for site activities. The configuration, timing, and duration of the activities must be specified in a way that conforms to the site's overall budget constraints.

2.6.2 Net Present Value Calculation and Comparison

NPVs must be calculated for both options. From the cash-flow schedules, each year's net cash flow will be discounted to present-year or year-zero values, using the appropriate discount rate established by the Office of Management and Budget (OMB) in OMB *Circular A-94*, revised periodically (see Appendix B). For project costs expressed in constant dollars, the OMB real discount rate should be used. For project costs escalated to show estimated actual costs (e.g., Project Baseline Summaries (PBS) out-year costs in *ACPC* are escalated at 2.7% per year), the effects of escalation must be removed before discounting with the OMB real discount rate.

After removing the effects of escalation, each year's constant-dollar cash flow is discounted using the following formula:

$$PV = F/(1 + i)^n ,$$

where

- PV = present value, an amount at time = 0 years,
- F = future value, an amount at the end of year n ,
- i = OMB real discount rate,
- n = number of years from year 0.

The summation of the yearly discounted cash flows of a project is the NPV of the project. The NPV is equivalent to an amount invested at time 0 that would earn sufficient annual interest over the project life (at a specified discount rate) to cover the annual costs. It is important to note that the PV of any future cash flow becomes less as the number of years increases. For projects with indefinite lifetimes, the PV of cash flows far in the future becomes negligible, even at relatively modest interest rates. Therefore, NPV analysis beyond a 50-year horizon is not generally necessary.

A hypothetical group of cash flows are presented in Table 2 to illustrate the relationship of cash flow amounts. Cash flows for two options are expressed in escalated dollars (at an escalation rate of 2.7% as per the 1997 *ACPC* guidance) and in constant (unescalated) dollars. Also shown are the yearly present values, which are obtained by discounting the constant-dollar cash flows using a discount rate of 3.5% (OMB real discount rate, 5 to 7 year projects, January 1998). Assuming the cash flows occur at the end of each period (end-of-year convention) and the entire stream of cash flows is evaluated from the basis of time zero at the beginning of year 1, the NPV is calculated to be \$24.09 million for the conventional system and \$18.18 million for the innovative system, as shown in Table 2.

Table 2
Cash flows and present values, costs in millions of dollars

| Option | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Total |
|----------------------|--------|--------|--------|--------|--------|--------|-------|
| <i>Conventional</i> | | | | | | | |
| Escalated \$ | 10.27 | 2.64 | 4.33 | 4.45 | 4.57 | 2.35 | 28.61 |
| Constant \$ | 10.00 | 2.50 | 4.00 | 4.00 | 4.00 | 2.00 | 26.50 |
| PV \$ | 9.66 | 2.33 | 3.61 | 3.49 | 3.37 | 1.63 | 24.09 |
| <i>Innovative</i> | | | | | | | |
| Escalated \$ | 12.32 | 1.58 | 1.62 | 1.67 | 3.43 | 0 | 20.63 |
| Constant \$ | 12.00 | 1.50 | 1.50 | 1.50 | 3.00 | 0 | 19.50 |
| PV \$ | 11.59 | 1.40 | 1.35 | 1.31 | 2.53 | 0 | 18.18 |
| Escalated \$ Savings | -2.05 | 1.05 | 2.71 | 2.78 | 1.14 | 2.35 | 7.98 |
| Constant \$ Savings | -2.00 | 1.00 | 2.50 | 2.50 | 1.00 | 2.00 | 7.00 |
| PV \$ Savings | -1.93 | 0.93 | 2.26 | 2.18 | 0.84 | 1.63 | 5.91 |

For the example given, the NPV dollar cost savings are +\$5.91 million; therefore, the innovative option is more cost-effective than the conventional option. For reporting purposes, the total escalated dollar cost savings are +\$7.98 million and the total constant dollar cost savings are +\$7.00 million.

2.7 Supplementary Cost Analyses

A number of other analyses are useful for examining the cost estimates. Sites are encouraged, but not required, to perform these analyses.

2.7.1 Break-Even Time

Break-even time is defined as that time required for the accumulated PV of yearly savings from an innovative technology deployment to offset the accumulated yearly expenditures required to accomplish deployment at the site (development costs are ignored since they are considered sunk). In some cases, the innovative technology costs less than the conventional technology from the very beginning of the project. In cases where the break-even time approaches zero, the innovative technology is clearly superior from a cost perspective. In other cases, the innovative technology may have higher capital cost than the conventional technology, and the offsetting savings will occur in the out-years.

In the example given above in Table 2, the innovative system requires an additional \$2 million in capital expenditure. This \$2 million cost difference has a PV of \$1.93 million. As the PV of

savings shows, \$0.93 million is recouped at the end of year 2, and an additional \$2.26 million is recouped at the end of year 3. The break-even point is then interpolated to occur at an elapsed time of 2.4 years (ignoring the intra-year effects of discounting).

Innovative technologies that have long break-even times should be considered carefully before a decision in favor of deployment. Technologies with long break-even times may become obsolete prior to break-even. In addition, the more time required for break-even, the more uncertain the estimate of the savings.

2.7.2 Sensitivity Analysis

The cost of an option may be sensitive to several cost drivers. Hydraulic conductivity of soils, level of contamination, and regulatory limits are examples of cost drivers pertaining to remediation technologies. A sensitivity analysis will determine which cost drivers significantly impact the cost of an option. It is particularly important to understand the sensitivities of key assumptions.

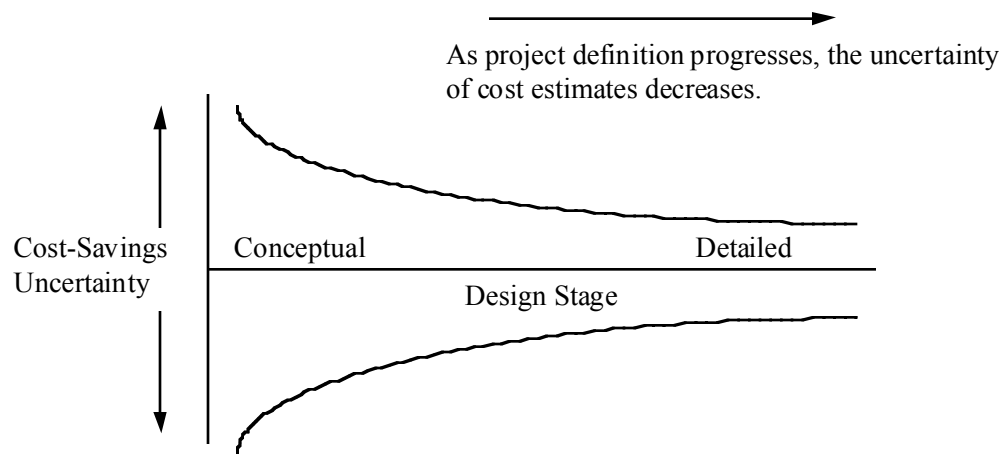
To generate data for a sensitivity analysis, several cost estimates are made for an option. For each estimate, one cost driver is varied while the remaining drivers are held constant. For instance, the processing rate for an innovative treatment process could be varied across a reasonable range of values, and the unit cost of the process will vary accordingly. The resulting unit costs are compared to the corresponding processing rates to determine whether the unit cost is sensitive to changes in processing rates.

Sensitivity analyses show which cost drivers are significant and which can be ignored when estimating technology-implementation cost. The individual sites can use this information when preparing site-specific cost estimates for technology implementations. Sensitivity analysis is key to identifying and documenting the cost factors and underlying assumptions that most greatly impact the total life-cycle costs.

2.7.3 Uncertainty Analysis

An uncertainty analysis allows the cost estimator to determine how much an estimated total cost may vary, given that elements of the total cost are uncertain. Instead of generating a point estimate for one configuration of an option, multiple estimates are made by varying the sensitive assumptions, elements, and cost factors to determine the range of variability for the option. Procedures for performing uncertainty analyses can be found in numerous economics texts, including *Economic Evaluation and Investment Decision Methods* (Stermole and Stermole 1993) and *Life-Cycle Cost and Economic Analysis* (Fabrycky and Blanchard 1991).

When uncertainty analyses are performed it must be understood that the uncertainty of the estimates should decrease as project definition progresses. Therefore, the need for uncertainty analyses decreases as the option becomes more mature. Figure 2 illustrates this point.



3. IMPLEMENTATION

3.1 Introduction

This section summarizes the basic principles that should be applied in the development and reporting of life-cycle cost savings. It also addresses actual implementation of the recommended approach, roles and responsibilities, and reporting of results. Future updates or replacement of the *ACPC* may require revision of this reporting guidance. However, the basic need for reporting of life-cycle cost savings will still be valid.

The methodology recognizes that the sites currently have processes in place that support cost analysis and reporting of potential life-cycle cost savings. Although processes between sites (or even at a given site) may not be identical, they all share common salient features. Examples of directly related processes include budget, decision making to evaluate alternatives, program and project management (including change control), and cost estimating (including life-cycle). Sites must determine when a life-cycle cost-savings analysis consistent with this methodology will be performed on a given project.

3.1.1 Use of Life-Cycle Cost Analyses Results Among Sites

While intersite cost comparisons would be beneficial to the complex, direct comparisons between sites are difficult because of the number of variables involved. These variables include items such as differing cost accounting practices, contract types and clauses of site contractors, organizational structure, code of accounts, and work breakdown structures. Comparison between conventional and innovative technologies can be valid only so long as a comparable estimating methodology is used for each and the assumptions and data elements are well understood and equalized, as appropriate.

Program and Project Managers should be aware of industry and other site's activities in the technology area in which they are working. Although cost-savings analysis are beneficial by themselves, the generator should be contacted for understanding the data make-up and use for other applications. The *ACPC* may not capture costs that are specific to a given technology; however, it is one indicator of technologies being explored by DOE sites.

3.1.2 Graded Approach

The rigor of analysis and application of this methodology should follow a “graded approach,” in keeping with the *Life-Cycle Asset Management* Order (DOE Order 430.1) and other DOE directives and policies, and OMB guidance. Thresholds for performing life-cycle cost-savings analyses will be determined by the sites. Increased effort in performing analyses should be applied to near-term deployments that provide the greatest potential for cost savings. Near-term deployments also will have the most-detailed baselines and better data for evaluation. However, there may be some longer-term (i.e., out-year) deployments that require increased rigor of evaluation, such as cases where visibility is high or when an early commitment or decision is necessary.

3.2 Roles and Responsibilities

The primary responsibility for generation of cost-savings analyses has been given to the DOE field site managers, with input and support from technology developers, focus areas, and possibly others. Figure 3 summarizes these roles and responsibilities.

| Field Site | Technology Developer | Focus Area |
|---|---|--|
| Develops field program and project needs | Champion for an innovative technology | Technology proponent |
| Maintains awareness of technological options that could apply to resolution of site issues by communication with other sites and industry, and (as appropriate) participation in technological development and application forums | Provides technology performance data, risks, assumptions, cost data, etc. | Provides technology cost, schedule, and performance data, plus assumptions and judgement of risk areas |
| Identifies innovative technology needs in the <i>ACPC</i> , Part C, Attachment F, Table O.9.2 | Assists focus area and field site as requested | Provides list of available technologies, and development and readiness status |
| Establishes baselines and budgets | | Works with field site to support development needs |
| Manages baselines and applies change-control processes | | Assists field site as requested |
| Analyzes alternative technologies (including life-cycle costs) | | |
| Selects most-beneficial alternatives through a decision process | | |
| Implements alternatives and revises baseline and budget documents | | |
| Reports potential life-cycle cost savings on annual update to <i>ACPC</i> , Part C, Attachment F, Table O.9.3 | | |
| Maintains documentation to support potential life-cycle cost savings claimed (plus additional backup as needed for other items above) | | |

Figure 3. Roles and responsibilities.

3.2.1 Field Sites

The field sites are responsible for developing program and project needs, establishing baselines and budgets for addressing those needs, and program/project execution. Consideration of innovative technology is also a site responsibility and they should pursue technologies that are cost effective where other factors are equal. The sites are required to develop and report cost savings that could result from the use of innovative technology in a manner consistent with this methodology.

3.2.2 Technology Developers

The sites must ensure that the analyses are consistent with methodology outlined in this document and ensure consistency of data with *ACPC* and other program/budget documents. However, the technology developer, as champion for an innovative technology, should provide the site with the most complete data on the technology so the site can evaluate the applicability to its specific mission. Thus, technology developers must actively coordinate with sites and be aware of their technology needs. Similarly, sites should solicit input from technology developers (and focus areas) when developing cost-savings analyses. Where available, a complete cost, schedule, and performance data package should be provided for the innovative technology, together with any life-cycle cost models previously developed. Assumptions used in the development of data and potential risks in applying the technology should be addressed by the technology developer.

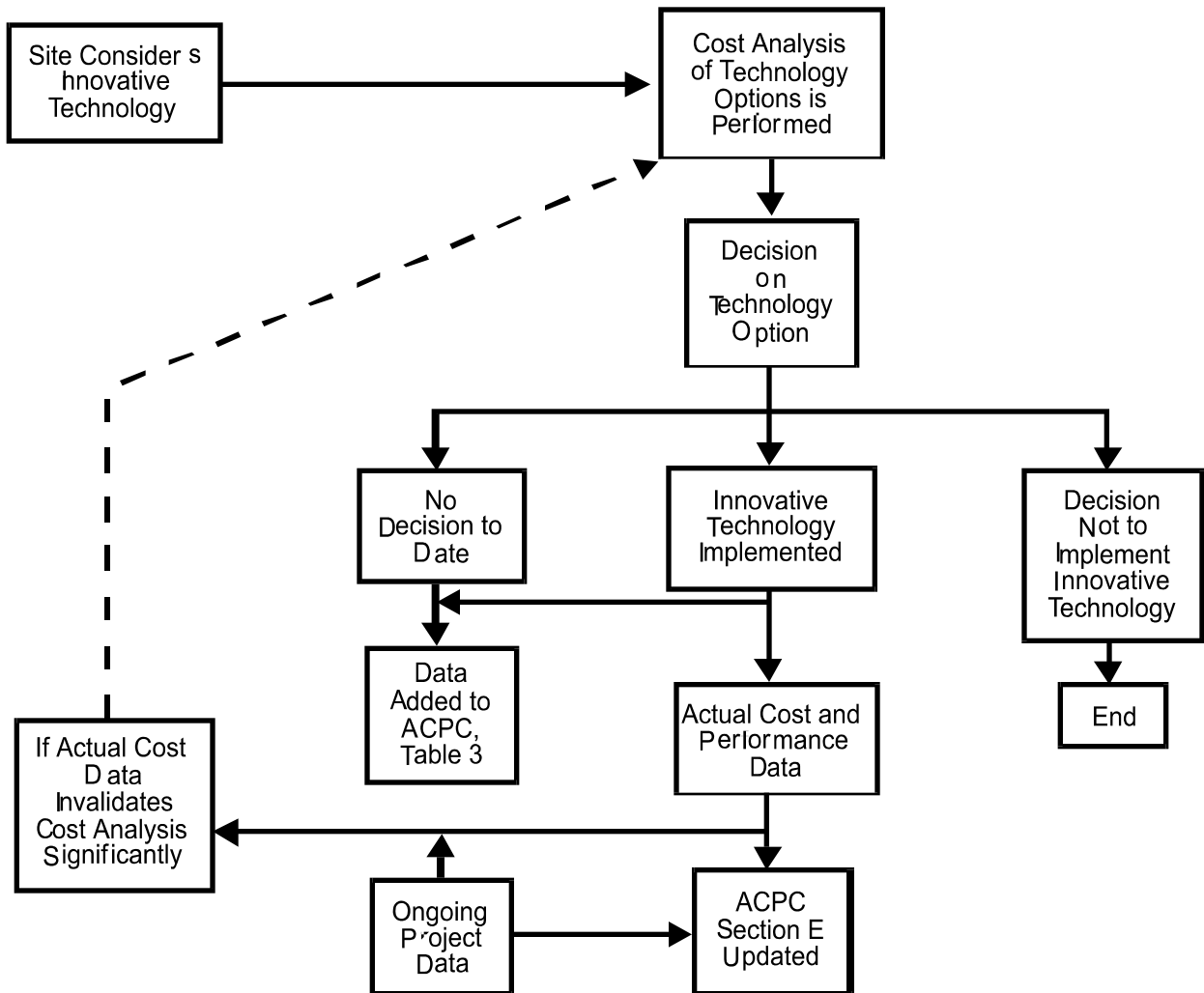
3.2.3 Focus Areas

As innovative technology resources, focus areas should provide available cost-analysis models and supporting documentation relevant to the performance and limitations of innovative technologies to appropriate field sites.

Cost analyses, and sometimes economic models, should be developed for all innovative technologies at the engineering-demonstration stage or later. Cost analyses of innovative technologies may have been developed during the technology review process. As with input from technology developers, data provided to field sites should be as complete as possible, including assumptions and potential risks.

3.3 Data Flow

Figure 4 illustrates the technology deployment decision and reporting processes. If the results of a cost savings analysis on an innovative technology are favorable but no decision has been made to deploy, the potential life-cycle cost savings are reported in the Operations/Field Office Summary, Part C, Table O.9.3 (referred to as Table 3 of *ACPC*) and the technology status is listed as “EP.” If the decision is made to deploy the technology, Table 3 is updated to reflect the potential life-cycle cost savings and the technology status is listed as “B” after it has been included in the budget. If it is decided not to deploy the innovative technology, the cost-savings analysis should be retained in the event that other DOE sites are interested in the technology and desire input.



As work is accomplished, actual data (including work scope deletions and cost performance) are reported in Section E of the specific individual PBS. Section E of *ACPC* includes eight categories that differentiate the sources of cost savings. One of these categories is for cost savings that result from the use of “new” technologies. These “new” technologies may include innovative technologies. If actual costs related to innovative technologies are of such a magnitude as to dictate revisions in the life-cycle cost savings shown in Table 3, then the process would be repeated.

3.4 Documentation and Reporting

Currently, the *ACPC* is the primary vehicle available to the sites for collecting and reporting innovative technology cost savings. The sites are responsible for the validity and defense of the data submitted, including the setting of internal thresholds for determining which technologies are analyzed and reported. Reporting should be in constant dollars. (See discussion in Section 2.6.)

3.4.1 *ACPC* Reporting

The *ACPC* reporting process was selected as the mechanism for reporting life-cycle cost savings from the potential implementation of innovative technologies. Using *ACPC* for reporting is expected to provide the following benefits:

- \$ consistency of data (because a separate reporting system is not required),
- \$ cost-effectiveness (because a separate organization and data repository need not be created),
- \$ reduction of burdensome multiple reporting.

ACPC includes several sections that apply to innovative technologies. The reporting requirements in Attachment F, Part C, “Innovative Technology Deployment,” are specifically applicable:

- \$ Table O.9.1, listing technologies selected for deployment;
- \$ Table O.9.2, identifying science and technology needs of the field site; and
- \$ Table O.9.3, listing innovative technology estimated life-cycle cost savings and other benefits.

Table O.9.3 should be used to report the estimated life-cycle cost savings from potential deployment of innovative technologies. This table should be updated annually along with other *ACPC* updates and submittals. The update would include:

- \$ new technology options that may have been introduced since the last submittal;
- \$ revisions to previous data submitted, based upon new information; and
- \$ potential life-cycle cost savings attributed to innovative technology from baseline changes.

Table O.9.3 includes the following data:

- \$ waste type or problem area
- \$ geographic site
- \$ innovative technology name
- \$ OST Technology Management System identification number
- \$ life-cycle cost savings (in constant dollars)
- \$ confidence in the estimate (high, medium, or low)
- \$ source/reference for the cost savings shown
- \$ site project identification number
- \$ project title
- \$ technology status and whether the life-cycle cost savings were already in the PBS baselines or are potential future baselines (“Enhanced Performance”)
- \$ comments

The comment column is used for (among other things) listing other benefits that are (or could be) realized with use of the innovative technology. Examples of benefits other than the site integrated life-cycle cost reduction are items such as potential cost savings to other sites, other Federal agencies, or industry; risk reduction to the project or environmental safety and health; schedule improvement; compliance; and waste reduction. Also, key assumptions or uncertainties that drive the life-cycle costs should be included in the comment column.

3.4.2 Future *ACPC* Reporting

This methodology was not in place when previous life-cycle cost savings in Table O.9.3 were submitted. The following are recommendations for future updates of this table:

- \$ Projected life-cycle savings are to be developed as deemed appropriate using this methodology to determine savings.
- \$ It is not required to reassess life-cycle cost savings using this methodology for previous submittals. However, field sites are responsible for the validity and defense of the data submitted. It is recommended that field sites evaluate the assumptions, basis, and documentation on these previous submittals in accordance with the approach proposed in this methodology. Where the field site does not feel that the existing basis or documentation is adequate for the stage of project development, corrective action should be taken, utilizing this methodology to the extent necessary.
- \$ Sites should consider the graded approach addressed in Section 3.1.2. They may want to establish thresholds for various rigors of analysis and documentation. They may want to focus on technologies being addressed in the near term in the Technology Deployment plan. It is not expected that complex or costly accounting systems be set up to document cost savings.

3.4.3 Other Reporting

Several other innovative technology reports include cost information: Technology Deployment Management Plans prepared by field sites, OST's Technology Management System, and the focus area Innovative Technology Summary Reports.

4. REFERENCES

1. Alm, A. July 3, 1997, Memorandum from the Assistant Secretary for Environmental Management to U.S. Department of Energy sites and organizations.
2. U.S. Department of Energy 1997, *Accelerating Cleanup: Paths to Closure (ACPC) Guidance*.
3. U.S. Department of Energy, *Life-Cycle Asset Management*, DOE Order 430.1.
4. Federal Remediation Technologies Roundtable 1995, *Guide to Documenting Cost and Performance for Remediation Projects*, EPA-542-B-95-002.
5. Interagency Cost Estimating Group 1998, *Hazardous, Toxic, and Radioactive Waste Work Breakdown Structure*.
6. U. S. Office of Management and Budget, *Circular A-94*.
7. Stermole, F. J., and J. Stermole 1993. *Economic Evaluation and Investment Decision Methods*, 8th ed., Investments Evaluations Corp.
8. Fabrycky, W. J., and B. S. Blanchard 1991, *Life-Cycle Cost and Economic Analysis*, Prentice Hall.

APPENDIX A. Example of Cost-Savings Analysis

| | | | | | |
|--|--|-------------------------------------|--|--|--|
| Estimate ID: NV04 | COST ESTIMATE SUMMARY | Page 1 of 2 Date: 4/17/98 | | | |
| TO: DOE/NV/ERD | | | | | |
| SUBJECT: Soil Volume Reduction | | | | | |
| <table style="width: 100%; border: none;"> <tr> <td style="width: 33%; vertical-align: top;"> TYPE OF ESTIMATE : <input type="checkbox"/> Order of Magnitude <input type="checkbox"/> Preliminary Title II <input checked="" type="checkbox"/> Preliminary/Planning/Study <input type="checkbox"/> Work Order <input type="checkbox"/> Conceptual/Budget <input type="checkbox"/> Comparative <input type="checkbox"/> Title I/Preliminary <input type="checkbox"/> Other </td> <td style="width: 33%; vertical-align: top;"> TYPE OF WORK: <input type="checkbox"/> RI/FS <input checked="" type="checkbox"/> Remediation <input type="checkbox"/> Construction <input type="checkbox"/> Other </td> <td style="width: 33%;"></td> </tr> </table> | | | TYPE OF ESTIMATE : <input type="checkbox"/> Order of Magnitude <input type="checkbox"/> Preliminary Title II <input checked="" type="checkbox"/> Preliminary/Planning/Study <input type="checkbox"/> Work Order <input type="checkbox"/> Conceptual/Budget <input type="checkbox"/> Comparative <input type="checkbox"/> Title I/Preliminary <input type="checkbox"/> Other | TYPE OF WORK: <input type="checkbox"/> RI/FS <input checked="" type="checkbox"/> Remediation <input type="checkbox"/> Construction <input type="checkbox"/> Other | |
| TYPE OF ESTIMATE : <input type="checkbox"/> Order of Magnitude <input type="checkbox"/> Preliminary Title II <input checked="" type="checkbox"/> Preliminary/Planning/Study <input type="checkbox"/> Work Order <input type="checkbox"/> Conceptual/Budget <input type="checkbox"/> Comparative <input type="checkbox"/> Title I/Preliminary <input type="checkbox"/> Other | TYPE OF WORK: <input type="checkbox"/> RI/FS <input checked="" type="checkbox"/> Remediation <input type="checkbox"/> Construction <input type="checkbox"/> Other | | | | |
| WORK TO BE PERFORMED BY: <input checked="" type="checkbox"/> DOE Prime Contractor <input type="checkbox"/> National Lab <input type="checkbox"/> NTS General <input type="checkbox"/> Subcontract <input type="checkbox"/> NTS Maintenance <input type="checkbox"/> Other | | | | | |
| STATEMENT OF WORK: <p>This is an estimate of cost savings from deploying the Segmented Gate System at the Clean Slate 2 and Clean Slate 3 soil remediation sites.</p> | | | | | |
| BASIS OF ESTIMATE: <p>The baseline cost for the Clean Slate 2 and Clean Slate 3 is taken from IT corporation's estimates. These estimates use a "template cost" as the basis, with baseline factors specific for each project multiplied times the template cost to determine the individual project baseline costs. Costs with the technology are based on information from the vendor, Thermo NUTECH, and field cost adjustments based on experience at Clean Slate 1.</p> | | | | | |
| ASSUMPTIONS: <p>The cost savings compares field costs with and without the technology in constant present day dollars. It is assumed that other project costs (e.g. engineering and administration) don't change with technology deployment. The SGS system is estimated to reduce the quantity of contaminated soil requiring transportation and disposal at the NTS by 70%. Assumed soil quantities processed are: Clean Slate 2 - 19,000 cu yds; Clean Slate 3 - 24,000 cu yds. See detailed estimate for additional assumptions.</p> | | | | | |
| RISK: <p>The estimate does contain an allowance for risk. The major unknown that could affect the cost savings is actual volume reduction performance. Thermo NUtech operating data show a range of volume reduction from about 50% to in excess of 90%.</p> | | | | | |

Review/Concurrence:

Estimator _____ Date: _____ Checked by _____ Date: _____

Estimate ID: NV04

COST ESTIMATE SUMMARY

Page 2 of 2

Date: 4/17/98

COST SUMMARY:

| | <u>Cost Savings (\$)</u> |
|--------------------------------|--------------------------|
| Labor | |
| Materials | |
| Engineering | |
| Construction | |
| Subcontracts | |
| Risk | |
| TOTAL ESTIMATED SAVINGS | \$30,000,000 |

| TECHNOLOGY DEPLOYMENT COST SAVINGS ESTIMATES | | | | | | | ehh 2/12/98 | | | |
|--|--------------|------------|------------------|-----------------------|------------|--------------|--------------|--------------------|--|--|
| NV04- SOIL VOLUME REDUCTION | | | | | | | rev. 3/20/98 | | | |
| | | | | | | | | | | |
| Project: Clean Slate 2 | | | | | | | | | | |
| | Template (1) | Baseline | Project Baseline | Technology Adjustment | Adjusted | Cost | | | | |
| Category and/or Activity | Cost (\$) | Factor (2) | Cost (\$) | (% or \$) (6) | Cost (\$) | Savings (\$) | | Comments | | |
| 1. Corrective Action Investigation Plan | | | | | | | | | | |
| Project Management | 112,906 | 0 | 0 | 0 % | 0 | 0 | | | | |
| Document Preparation | 119,608 | 0 | 0 | 0 % | 0 | 0 | | | | |
| Data Quality Objectives | 2,898 | 0 | 0 | 0 % | 0 | 0 | | | | |
| Technical Support | 40,744 | 0 | 0 | 0 % | 0 | 0 | | | | |
| Rad Risk Assessment | 30,741 | 0 | 0 | 0 % | 0 | 0 | | | | |
| CAIP Total | 306,897 | | 0 | | 0 | 0 | | Note 5 | | |
| 2. Corrective Action Decision Document | | | | | | | | | | |
| Project Management | 112,906 | 1 | 112,906 | 0 % | 112,906 | 0 | | | | |
| Analytical Sampling | 233,798 | 1 | 233,798 | 0 % | 233,798 | 0 | | | | |
| Field Geophysics | 34,686 | 1 | 34,686 | 0 % | 34,686 | 0 | | | | |
| Document Preparation | 207,042 | 1 | 207,042 | 0 % | 207,042 | 0 | | | | |
| DRI Document Support | 12,401 | 1 | 12,401 | 0 % | 12,401 | 0 | | | | |
| Historical Evaluation | 39,179 | 1 | 39,179 | 0 % | 39,179 | 0 | | | | |
| BN Document Support | 231,862 | 1 | 231,862 | 0 % | 231,862 | 0 | | | | |
| Wind Tunnel | 96,052 | 1 | 96,052 | 0 % | 96,052 | 0 | | | | |
| SSPSS Pre-remediation | 59,425 | 1 | 59,425 | 0 % | 59,425 | 0 | | | | |
| Ambient Monitoring-pre | 97,874 | 1 | 97,874 | 0 % | 97,874 | 0 | | | | |
| Cultural Resources Survey | 19,374 | 1 | 19,374 | 0 % | 19,374 | 0 | | | | |
| CADD Total | 1,144,599 | | 1,144,599 | | 1,144,599 | 0 | | | | |
| 3. Corrective Action Plan | | | | | | | | | | |
| Document Preparation | 179,109 | 1 | 179,109 | 0 % | 179,109 | 0 | | | | |
| Technical Support | 30,652 | 1 | 30,652 | 0 % | 30,652 | 0 | | | | |
| CAP Total | 209,761 | | 209,761 | | 209,761 | 0 | | | | |
| 4. Closure/Report | | | | | | | | | | |
| Field Work Prep | 150,321 | 1 | 150,321 | \$50,000 | 200,321 | -50,000 | | BN support to SGS | | |
| Field Work Labor | 230,730 | 1 | 230,730 | \$100,000 | 330,730 | -100,000 | | BN support to SGS | | |
| Field Work ODCs | 85,226 | 1 | 85,226 | \$30,000 | 115,226 | -30,000 | | BN support to SGS | | |
| Waste Characterization | 185,088 | 1 | 185,088 | 0 % | 185,088 | 0 | | | | |
| Excavation Labor | 254,431 | 6 | 1,526,586 | 0 % | 1,526,586 | 0 | | | | |
| Excavation ODCs | 162,485 | 6 | 974,910 | 0 % | 974,910 | 0 | | | | |
| Packing/Disposal Labor | 890,585 | 6 | 5,343,510 | -70 % | 1,603,053 | 3,740,457 | | Note 10 | | |
| Packing/Disposal ODCs | 522,775 | 6 | 3,136,650 | -70 % | 940,995 | 2,195,655 | | Note 10 | | |
| Transportation (4) | 920,000 | 6 | 5,520,000 | -70 % | 1,656,000 | 3,864,000 | | Note 10 | | |
| Disposal Fee (3) | 1,225,000 | 6 | 7,350,000 | -70 % | 2,205,000 | 5,145,000 | | Note 10 | | |
| Reclamation | 286,282 | 6 | 1,717,692 | 0 % | 1,717,692 | 0 | | | | |
| Document Preparation | 53,096 | 1 | 53,096 | 0 % | 53,096 | 0 | | | | |
| Ambient Monitoring | 46,483 | 1 | 46,483 | 0 % | 46,483 | 0 | | | | |
| Technical Support | 202,240 | 1 | 202,240 | 0 % | 202,240 | 0 | | | | |
| Insitu Remediation | 236,648 | 1 | 236,648 | 0 % | 236,648 | 0 | | | | |
| Insitu Remediation Lab | 110,415 | 1 | 110,415 | 0 % | 110,415 | 0 | | | | |
| SGS Deployment (7) | | | 0 | \$150,000 | 150,000 | -150,000 | | Thermo NUtech cost | | |
| SGS Operation (8) | | | 0 | \$1,425,000 | 1,425,000 | -1,425,000 | | Thermo NUtech cost | | |
| SGS Decon/Demob (7) | | | 0 | \$70,000 | 70,000 | -70,000 | | Thermo NUtech cost | | |
| Clean Soil Backfill | | | 0 | \$350,000 | 350,000 | -350,000 | | Note 9 | | |
| Closure/Report Total | 5,561,805 | | 26,869,595 | | 13,749,483 | 13,120,112 | | | | |
| 5. Post Closure Activities | | | | | | | | | | |
| Ambient Monitoring-post | 98,124 | 1 | 98,124 | 0 % | 98,124 | 0 | | | | |
| SSPSS post-remediation | 82,470 | 1 | 82,470 | 0 % | 82,470 | 0 | | | | |
| PCA Wind Tunnel | 96,052 | 1 | 96,052 | 0 % | 96,052 | 0 | | | | |
| Post Closure Act. Total | 276,646 | | 276,646 | | 276,646 | 0 | | | | |
| CLEAN SLATE 2 TOTALS | 7,499,708 | | 28,500,601 | | 15,380,489 | 13,120,112 | | | | |

| Project: Clean Slate 3 | | | | | | | |
|---|-----------|--------------|------------|--------------------|---------------------------|--------------------|-------------------|
| | | Template (1) | | Project | | | |
| Category and/or Activity | | Cost (\$) | Factor (2) | Baseline Cost (\$) | Technology Adjustment (6) | Adjusted Cost (\$) | Cost Savings (\$) |
| 1. Corrective Action Investigation Plan | | | | | | | |
| Project Management | 112,906 | 0 | | 0 | 0 % | 0 | 0 |
| Document Preparation | 119,608 | 0 | | 0 | 0 % | 0 | 0 |
| Data Quality Objectives | 2,898 | 0 | | 0 | 0 % | 0 | 0 |
| Technical Support | 40,744 | 0 | | 0 | 0 % | 0 | 0 |
| Rad Risk Assessment | 30,741 | 0 | | 0 | 0 % | 0 | 0 |
| CAIP Total | 306,897 | | | 0 | | 0 | 0 |
| 2. Corrective Action Decision Document | | | | | | | |
| Project Management | 112,906 | 1 | | 112,906 | 0 % | 112,906 | 0 |
| Analytical Sampling | 233,798 | 1 | | 233,798 | 0 % | 233,798 | 0 |
| Field Geophysics | 34,686 | 1 | | 34,686 | 0 % | 34,686 | 0 |
| Document Preparation | 207,042 | 1 | | 207,042 | 0 % | 207,042 | 0 |
| DRI Document Support | 12,401 | 1 | | 12,401 | 0 % | 12,401 | 0 |
| Historical Evaluation | 39,179 | 1 | | 39,179 | 0 % | 39,179 | 0 |
| BN Document Support | 231,862 | 1 | | 231,862 | 0 % | 231,862 | 0 |
| Wind Tunnel | 96,052 | 1 | | 96,052 | 0 % | 96,052 | 0 |
| SSPSS Pre-remediation | 59,425 | 1 | | 59,425 | 0 % | 59,425 | 0 |
| Ambient Monitoring-pre | 97,874 | 1 | | 97,874 | 0 % | 97,874 | 0 |
| Cultural Resources Survey | 19,374 | 1 | | 19,374 | 0 % | 19,374 | 0 |
| CADD Total | 1,144,599 | | | 1,144,599 | | 1,144,599 | 0 |
| 3. Corrective Action Plan | | | | | | | |
| Document Preparation | 179,109 | 1 | | 179,109 | 0 % | 179,109 | 0 |
| Technical Support | 30,652 | 1 | | 30,652 | 0 % | 30,652 | 0 |
| CAP Total | 209,761 | | | 209,761 | | 209,761 | 0 |
| 4. Closure/Report | | | | | | | |
| Field Work Prep | 150,321 | 1 | | 150,321 | \$50,000 | 200,321 | -50,000 |
| Field Work Labor | 230,730 | 1 | | 230,730 | \$100,000 | 330,730 | -100,000 |
| Field Work ODCs | 85,226 | 1 | | 85,226 | \$30,000 | 115,226 | -30,000 |
| Waste Characterization | 185,088 | 1 | | 185,088 | 0 % | 185,088 | 0 |
| Excavation Labor | 254,431 | 8 | | 2,035,448 | 0 % | 2,035,448 | 0 |
| Excavation ODCs | 162,485 | 8 | | 1,299,880 | 0 % | 1,299,880 | 0 |
| Packing/Disposal Labor | 890,585 | 8 | | 7,124,680 | -70 % | 2,137,404 | 4,987,276 |
| Packing/Disposal ODCs | 522,775 | 8 | | 4,182,200 | -70 % | 1,254,660 | 2,927,540 |
| Transportation (4) | 920,000 | 8 | | 7,360,000 | -70 % | 2,208,000 | 5,152,000 |
| Disposal Fee (3) | 1,225,000 | 8 | | 9,800,000 | -70 % | 2,940,000 | 6,860,000 |
| Reclamation | 286,282 | 8 | | 2,290,256 | 0 % | 2,290,256 | 0 |
| Document Preparation | 53,096 | 1 | | 53,096 | 0 % | 53,096 | 0 |
| Ambient Monitoring | 46,483 | 1 | | 46,483 | 0 % | 46,483 | 0 |
| Technical Support | 202,240 | 1 | | 202,240 | 0 % | 202,240 | 0 |
| Insitu Remediation | 236,648 | 1 | | 236,648 | 0 % | 236,648 | 0 |
| Insitu Remediation Lab | 110,415 | 1 | | 110,415 | 0 % | 110,415 | 0 |
| SGS Deployment (7) | | | | | \$150,000 | 150,000 | -150,000 |
| SGS Operation (8) | | | | | \$1,800,000 | 1,800,000 | -1,800,000 |
| SGS Decon/Demob (7) | | | | | \$70,000 | 70,000 | -70,000 |
| Clean Soil Backfill | | | | | \$455,000 | 455,000 | -455,000 |
| Closure/Report Total | 5,561,805 | | | 35,392,711 | | 18,120,895 | 17,271,816 |
| 5. Post Closure Activities | | | | | | | |
| Ambient Monitoring-post | 98,124 | 1 | | 98,124 | 0 % | 98,124 | 0 |
| SSPSS post-remediation | 82,470 | 1 | | 82,470 | 0 % | 82,470 | 0 |
| PCA Wind Tunnel | 96,052 | 1 | | 96,052 | 0 % | 96,052 | 0 |
| Post Closure Act. Total | 276,646 | | | 276,646 | | 276,646 | 0 |
| CLEAN SLATE 3 TOTALS | 7,499,708 | | | 37,023,717 | | 19,751,901 | 17,271,816 |
| TOTAL CLEAN SLATE 2 PLUS 3 COST | | | | 65,524,318 | | 35,132,390 | 30,391,928 |

[illegible]

Cash Flows and Present Values

| Fiscal Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | TOTAL |
|----------------------------------|---------------|--------------|--------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|
| NTS Budget Constraint | \$ 509,000 | \$ 1,902,000 | \$ 4,527,000 | \$ 5,785,000 | \$ 8,359,000 | \$ 23,492,000 | \$ 26,625,000 | \$ 36,277,000 | \$ 47,637,000 | |
| CONVENTIONAL | | | | | | | | | | |
| Escalated Cash Flow (2.7%) | \$ 1,253,870 | \$ 1,106,605 | \$ 5,151,644 | \$ 6,435,542 | \$ 9,550,070 | \$ 26,693,259 | \$ 17,170,645 | \$ 8,988,309 | \$ 117,139 | \$ 76,467,083 |
| Baseline Cash Flow CS2 and CS3 | \$ 1,220,906 | \$ 1,049,184 | \$ 4,755,920 | \$ 5,785,000 | \$ 8,359,000 | \$ 22,749,871 | \$ 14,249,299 | \$ 7,262,973 | \$ 92,165 | \$ 65,524,318 |
| Present Value (Discounted) | \$ 1,178,481 | \$ 977,535 | \$ 4,277,158 | \$ 5,021,857 | \$ 7,004,152 | \$ 18,400,109 | \$ 11,124,365 | \$ 5,473,138 | \$ 67,039 | \$ 53,523,833 |
| Escalation Rate (ACPC) | 2.7% | | | | | | | | | |
| Discount Rate (10 year OMB) | 3.6% | | | | | | | | | |
| NPV of Cost (Conventional) | \$ 53,523,833 | | | | | | | | | |
| INNOVATIVE | | | | | | | | | | |
| Escalated Cash Flow (2.7%) | \$ 1,253,870 | \$ 1,106,605 | \$ 247,968 | \$ 6,435,542 | \$ 9,549,698 | \$ 21,586,509 | \$ 111,060 | \$ - | \$ - | \$ 40,291,253 |
| Innovative Cash Flow CS2 and CS3 | \$ 1,220,906 | \$ 1,049,184 | \$ 228,920 | \$ 5,785,000 | \$ 8,358,675 | \$ 18,397,540 | \$ 92,165 | \$ - | \$ - | \$ 35,132,390 |
| Present Value (Discounted) | \$ 1,179,619 | \$ 979,424 | \$ 206,473 | \$ 5,041,293 | \$ 7,037,780 | \$ 14,966,411 | \$ 72,441 | \$ - | \$ - | \$ 29,483,441 |
| Discount Rate (7 year OMB) | 3.5% | | | | | | | | | |
| NPV of Cost (Innovative) | \$ 29,483,441 | | | | | | | | | |
| | | | | | | | | | | |
| Escalated Dollar Savings: | \$ 36,175,829 | | | | | | | | | |
| Constant Dollar Savings: | \$ 30,391,928 | | | | | | | | | |
| NPV Dollar Savings: | \$ 24,040,391 | | | | | | | | | |

ASSUMPTIONS:

1. The baseline and innovative cash flows are expressed in constant dollars.
2. The cash flows are constrained by the Nevada Test Site soils remediation budget.
3. The cash flow example is for illustrative purposes only and does not reflect any decision by the Nevada Test Site to deploy the segmented gate technology under a specific schedule.
4. The baseline cash flows are discounted using the OMB real discount rate for 10 year projects (January 1998 guidance).
5. The innovative cash flows are discounted using the OMB real discount rate for 7 year projects (January 1998 guidance).
6. The escalation rate of 2.7% is taken from the ACPC guidance.

APPENDIX B. Discount Rates for Cost-Effectiveness

(Revised January 1998)

Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses

Effective Dates. This appendix is updated annually around the time of the President's budget submission to Congress. This version of the appendix is valid through the end of January, 1999. Copies of the updated appendix and the Circular can be obtained from the OMB Publications Office (202-395-7332) or in electronic form through the OMB home page on the Internet:

<http://www.whitehouse.gov/WH/EOP/omb>

Updates of this appendix are also available upon request from OMB's Office of Economic Policy (202-395-3381), as is a table of past years' rates.

Nominal Discount Rates. Nominal interest rates based on the economic assumptions from the budget are presented below. These nominal rates are to be used for discounting nominal flows, which are often encountered in lease-purchase analysis.

Nominal interest rates on treasury notes and bonds of specified maturities (percent)

| 3-Year | 5-Year | 7-Year | 10-Year | 30-Year |
|--------|--------|--------|---------|---------|
| 5.6 | 5.7 | 5.8 | 5.9 | 6.1 |

Real Discount Rates. Real interest rates based on the economic assumptions from the budget are presented below. These real rates are to be used for discounting real (constant-dollar) flows, as is often required in cost-effectiveness analysis.

Real interest rates on treasury notes and bonds of specified maturities (percent)

| 3-Year | 5-Year | 7-Year | 10-Year | 30-Year |
|--------|--------|--------|---------|---------|
| 3.4 | 3.5 | 3.5 | 3.6 | 3.8 |

Analyses of programs with terms different from those presented above may use a linear interpolation. For example, a four-year project can be evaluated with a rate equal to the average of the three- and five-year rates. Programs with durations longer than 30 years may use the 30-year interest rate.

APPENDIX C. Glossary

ACPC , *Accelerating Cleanup: Paths to Closure*, title of current EM cleanup strategy.

break-even time , that time required for the accumulated present value of yearly savings from an innovative technology deployment to offset the accumulated yearly expenditures required to make the deployment (development costs are ignored since they are considered sunk). Time period where costs of options being evaluated are equal. Time starts at time of evaluation or at time of deployment. Costs prior to the starting point (sunk costs) are excluded.

cash flow , the amount of money that is paid out (cash outflow) or taken in (cash inflow). In the evaluation of a project, cash flows are typically aggregated into yearly amounts.

constant dollars , a dollar value with constant purchasing value over time. Constant dollars are not adjusted for changes in prices.

conventional technology , the standard or accepted technology used to perform a function (may or may not be that used in the baseline).

cost-effectiveness , a measure of the cost required for achieving a given objective.

cost-effectiveness analysis , a systematic, quantitative method for comparing the cost of alternative means of achieving the same stream of benefits or a given objective.

cost savings , in the context of this methodology, the *potential* savings that would result if an innovative technology system were to replace a conventional technology system. The cost-savings analysis is made by comparing the life-cycle costs of the two alternatives.

discounted cash flow , the cash flow (including outflow and inflow) that has been adjusted to a present value with the appropriate discount rate.

discount rate , the interest rate used in calculating the present value of expected yearly savings and costs. For the purposes of these analyses, it is taken from Appendix C of OMB *Circular No. A-94*, updated annually.

enabling technology , a technology that is developed to address an Environmental Management need that has no conventional technological solution.

escalated dollars , the dollar value of goods or services, in terms of prices current at the time of sale (inflation is included in the dollar value). DOE and other government agencies prepare their budget requests in escalated dollars.

escalation rate , the yearly rate at which costs are forecast to change, due to price increases over time.

focus area , a major remediation and waste-management problem area within the DOE complex that has been targeted for action, based on risk, prevalence, or the need for technology development to meet environmental requirements and regulations.

Hazardous, Toxic, and Radioactive Waste Work Breakdown Structure , a work breakdown structure that was developed by the Interagency Cost Estimating Group for reporting the cost of remedial actions.

innovative technology , a new or alternative method for performing a function (as opposed to a conventional technology). Also referred to as “new” or “alternative” technology. For the purposes of this methodology, an innovative technology is always considered to be innovative, even after multiple deployments.

life-cycle costs , all direct and indirect costs, all initial costs, including planning and other costs or procurement; all periodic or continuing costs of operation and maintenance; and costs of decommissioning and disposal.

net present value , the sum of the discounted cash flows (inflows *and* outflows; costs *and* savings) over the life of the program.

present value , a single discounted cash flow amount (inflow *or* outflow).